

# SCIENCE FOR CERAMICS PRODUCTION

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## DURABLE POROUS CERAMIC MATERIAL IN APPARATUS FOR MONITORING ANTICORROSION PROTECTION OF MAIN PIPELINES

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Mix compositions are synthesized and their sintering conditions for the production of ceramic lugs are determined. The ceramic structure obtained makes it possible to increase 8 – 10-fold the service life of thimbles used in an apparatus for monitoring the anticorrosion protection of main pipelines.

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The transportable Poisk-1 apparatus is widely used to monitor the serviceability of cathodic corrosion protection of underground pipelines and to search for defects in insulation. The operation of the apparatus is based on measuring a potential by the method of synchronous interruption of cathodic protection currents. In the apparatus, a nonpolarizing copper-sulfate electrode is used as a potential sensor embedded in the ground. It consists of a dielectric tube filled with a chemically pure copper sulfate solution into which an electrode made of electrolytic copper is inserted; the electrode is terminated with a sharpened hollow, porous, ceramic thimble. The electrolyte present in the tube seeps through the through-pores in the thimble and thereby establishes an electric contact between the electrode and the soil.

The effectiveness of the Poisk-1 apparatus depends strongly on the structure of the thimble. Its walls must possess through porosity which would pass one drop of electrolyte in 30 – 40 sec under the pressure of a 600 – 1000 mm high column of electrolyte in the tube. The service life of the ceramic thimbles which are part of the apparatus is no more than 3 months, which is entirely inadequate. The reason of this rapid degradation is low strength of the ceramic and, first and foremost, low wearability.

In this connection we have posed the problem of finding a method of improving these properties. The wearability is most easily increased by increasing the content of the glass phase in the ceramic. To this end it is possible to use one of two generally known methods [1]. The first one is firing at a higher temperature, and the second one is introducing finished glass into the initial mix. But, densification of the article will occur in either case, i.e., its porosity will decrease.

To overcome this conflicting situation, the plan was to obtain, in the course of formation and then sintering, the material structure of the future part in the form of a three-dimensional lattice with uniformly distributed voids which communicate with one another [2, 3]. Such a lattice (framework) should possess adequate stiffness and refractoriness so that appreciable shrinkage and thereby undesirable densification do not occur during sintering. To impart strength each lattice site must be encased in a glass shell, and in the contact zones the sites of the indicated shell must be strongly welded to one another.

The problem pose above reduced to formation in the ceramic of a glassy chamotte refractory with 0.25 – 0.14 mm grains. The voids were produced by loose packing of chamotte and a consumable additive — anthracite coal with the same granulometric composition. The connectedness of the framework was achieved by using refractory clay from the Vladimir deposit. This same component made it possible to form an intermediate product by casting from slip in a gypsum mold. In order that the clay component not fill the intergrain voids, formed by the chamotte grains, the amount of clay must be as low as possible but adequate to impart satisfactory casting properties to the slip. Preliminary experiments established that the amount of clay must not exceed 30%.<sup>2</sup>

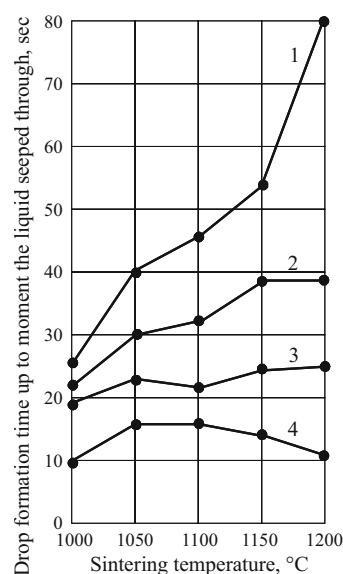
The strengthening glass binder was obtained by synthesis of glassy products of the high temperature interaction between the frit, clay, and chamotte introduced into the mix.

The experimental compositions (see Table 1) were prepared by mixing clay dispersed in water with fractionated chamotte and coal grains as well as frit, comminuted in a ball mill to particles which pass through a No. 006 sieve. The

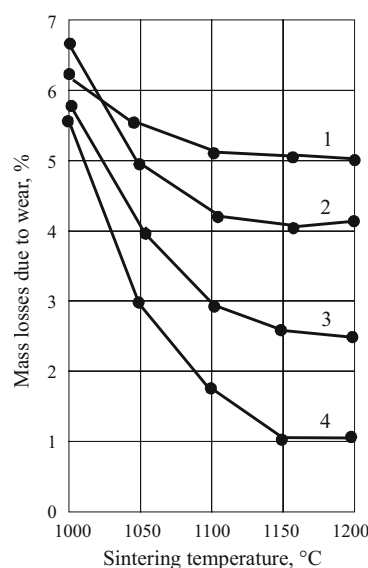
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<sup>2</sup> Here and below — content by weight.



**Fig. 1.** Effect of the sintering temperature of the samples based on their ability to pass a liquid. The numbers on the curves correspond to the mixes.



**Fig. 2.** Wearability of the samples versus the sintering temperature. The labeling is the same as in Fig. 1.

moisture content of the mix was 40 – 45%. Liquid glass and calcinated soda were added to the slip to obtain the required casting properties. The dried castings were sintered at temperatures 1000 – 1200°C with step 50°C and held for 1 h at the maximum temperature.

To determine the porosity of the ceramic water under pressure 600 – 1000 mm Hg was fed into the sintered thimbles and the seepage time of the drop — from the moment a thimble was filled with water and the water seeped through — was measured (Fig. 1). The degree of wearability was monitored according to the mass losses [4].

Figures 1 and 2 show that to a first approximation both the permeability and durability vary as the frit content. In addition, with up to 8% frit in the mix during sintering the frit melts mainly at 1050°C. Its viscosity at the same temperature increases as a result of the very low dissolution of chamotte in the liquid phase and the interaction with clay. Consequently, further increasing the temperature to 1200°C does greatly affect the durability. Investigations under a microscope showed that the sintered material consists of a monolithic mass of chamotte grains, strongly bound to one another by the sintered clay, and microregions of melted glass.

In samples with 16% frit content, after the frit melts at 1050°C, the refractory components in the liquid phase that is formed continue to melt, though more slowly, as temperature increases. Ultimately, as a result of this process the framework loses some stiffness, and the shrinkage due to sintering

increases substantially. In consequence, the filtration capacity decreases (see Fig. 1). The sintered (1150°C) ceramic consists of half-dissolved chamotte grains, bound into a monolith by a continuous lattice of a semitransparent non-uniform glass phase. The entire volume of the samples is permeated with a large number of relatively small pores.

Samples with 12% frit occupy an intermediate position with respect to the intensity and degree of development of the vitrification processes, i.e., by 1150°C chamotte dissolution slows down and practically stops. On the basis of the filtering capacity, this composition is optimal and the durability of the thimbles made from it is much higher, which fully solves the problems posed.

Field tests showed that the service life of the batch of thimbles (200 pieces) made with the composition indicated above and sintered at 1150°C is 8 – 10 times longer than that of the base samples.

The technological techniques described in this article could be helpful in the synthesis of high-strength materials with a wide range of through porosity, including articles with a complex shape.

## REFERENCES

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**TABLE 1.**

| Component | Content in experimental mixes, % |    |    |    |
|-----------|----------------------------------|----|----|----|
|           | 1                                | 2  | 3  | 4  |
| Clay      | 30                               | 30 | 30 | 30 |
| Chamotte  | 46                               | 44 | 42 | 40 |
| Coal      | 20                               | 18 | 16 | 14 |
| Frit      | 4                                | 8  | 12 | 16 |